Exploration Brief

Different Gravity

Context

Gravity is an attractive force that all objects have for one another. It doesn't matter whether the object is a planet, a cannon ball, a feather, or a person. Each exerts a gravitational force on all other objects around it.

The amount of the gravitational force between two objects is directly proportional to the product of their two masses and inversely proportional to the square of the distance between their centers of mass. This relationship is expressed in the equation below. M1 and M2 are the respective masses of the two objects and r is the distance between their centers of mass. G is the gravitational constant.

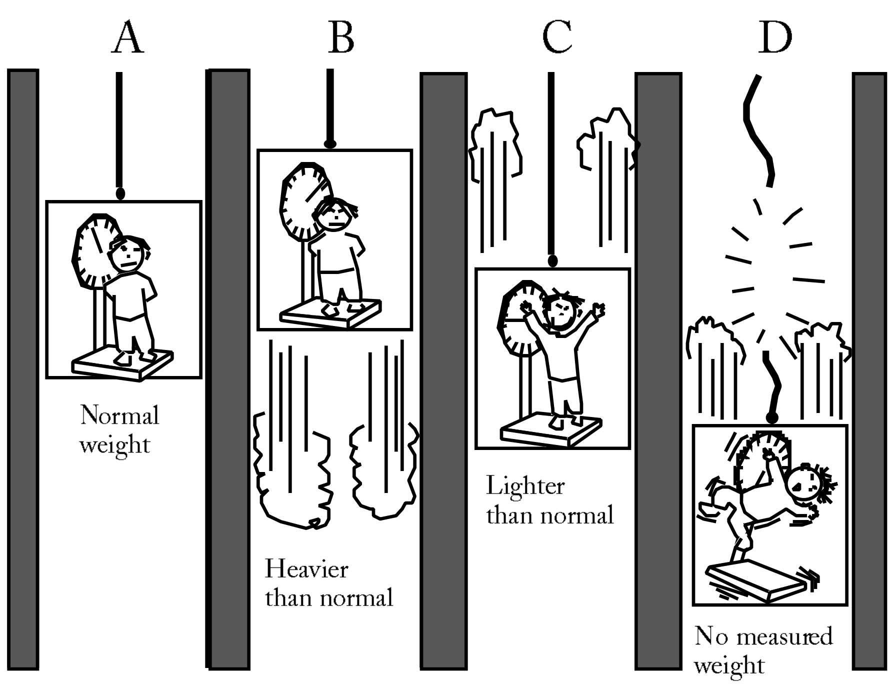
$$f = G\,\frac{m_1 m_2}{r^2}$$

By referring to this equation, we can see that the force of gravity is not constant. The amount depends upon local conditions. For example, an astronaut walking on the surface of the Moon would weigh only 1/6th what he or she would weigh on the surface of Earth. That same astronaut would weigh about 2/5ths as much on the surface of Mars. The reason for the difference is that the Moon and Mars are less massive bodies than Earth and they have smaller radii. Less mass reduces the amount of gravity experienced on the surface of the Moon and Mars while the smaller radii increases it.

Besides being altered by mass and distance, our perception of gravity's pull can also be altered by motion. Gravity can be made to appear to increase by accelerating away from Earth, as in a rocket liftoff or by riding on a centrifuge. Gravity can be made to appear to decrease by falling. NASA calls the environment created by falling microgravity.

You can get an idea of how this works by looking at the diagram on the next page. Imagine riding in an elevator to the top floor of a very tall building. At the top, the cables supporting the car break, causing the car and you to fall to the ground. (In this example, we discount the effects of air friction on the falling car.) Since you and the elevator car are falling together, you feel like you are floating inside the car. In other words, you and the elevator car are accelerating downward at the same rate due to gravity alone.If a scale were present, your weight would not register because the scale would be falling too. The ride is lots of fun until you get to the bottom! NASA calls this floating condition microgravity. The condition is experienced in orbit and in transit between planetary bodies.

Astronauts experience many different gravity environments during space travel and these environments make different demands on the spacesuits they wear. When designing a spacesuit, it is important to know in which gravity environments the suit will be worn. For example, greater strain will be placed on fluid pumping systems if the pump has to work against gravity than if it works in a microgravity situation. On an Apollo Moon landing mission, spacesuits were worn during liftoff when high G (gravity) forces were felt because of the acceleration. The suits were worn during lunar walks where the gravity was 1/6th that of Earth's gravity. Finally, the suits were worn in a microgravity environment during spacewalks while they coasted back from the Moon. Space Shuttle spacesuits are worn only in microgravity during space walks in Earth orbit. Suits worn on the surface of Mars may have to be modified to function in the 2/5ths g that will be experienced there.



(A) The person in the stationary elevator car experiences normal weight.(B) In the car immediately to the right, weight increases slightly because of the upward acceleration. (C) Weight decreases slightly in the next car because of the downward acceleration.(D) No weight is measured in the last car on the right because of freefall.

Investigation: Creating Microgravity

Microgravity is easy to create. It is merely a matter of dropping objects.By falling, gravity's local effects are greatly reduced.That means that if two objects are falling together, gravity's influence on them becomes nearly zero. For example, if a heavy weight is suspended from an elastic cord, the cord will stretch out. If the cord is released, the weight and cord begin to fall to the floor. With gravity's effects greatly reduced, the cord immediately retracts to its relaxed length.The following activities are methods of creating microgravity in the classroom.

Materials and Tools Checklist

- ☐ Paper cup
- ☐ Masking tape
- ☐ Rubber band (thin)
- ☐ Several washers or nuts
- ☐ Scissors

Objective

• To investigate microgravity.

Procedure

Step 1. *Cut the rubber band and tie one end to the nuts or washers. The nuts or washers should be heavy enough to stretch the rubber band when suspended from the free end.*

Step 2. *Tape the free end of the rubber band to the inside of the cup.*

Step 3. *Hold the cup upside down. Slowly turn the cup right side up so that the nuts or washers hang outside the cup.*

Step 4. *Drop the cup to the floor from eye level. Observe what happens to the weights.*

Step 5. *Discuss the implications of microgravity on spacesuit design. For example, how can fluids (water cooling system, gas circulation, etc.) be moved in microgravity?*

Extensions

- Challenge students to come up with a way of simulating the 2/5ths gravity of Mars.
- Obtain a copy of the NASA curriculum supplement *Microgravity—Activity Guide for Science, Mathematics, and Technology Education, EG-1997-08-110-HQ*. The guide contains plans and instructions for several additional microgravity demonstrations.